

MODEL CRAFT

Building a Twin Cylinder RACING GAS ENGINE

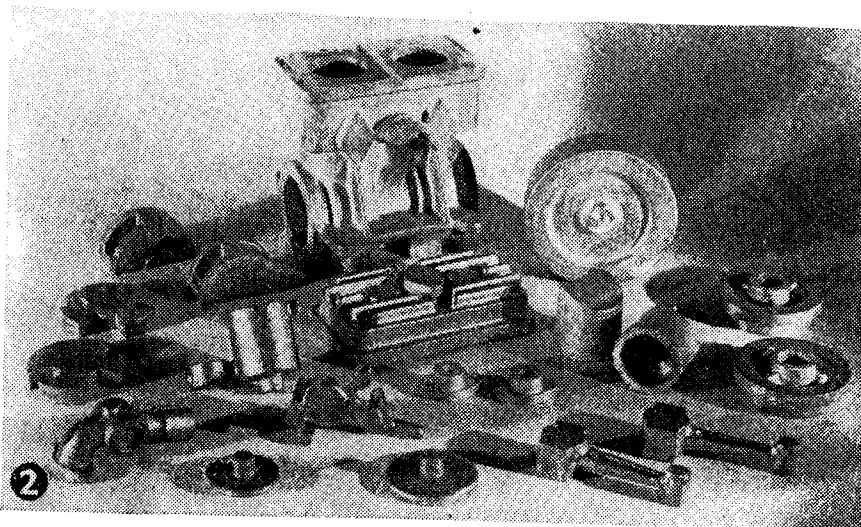
Here's a Model Craft project that will challenge the interest of all model makers. First of 2 parts.

By GARY MOORE

Craft Print Project No. 61

THERE is something about the building of a high speed miniature racing engine that appeals to every modelmaker. Perhaps the appeal lies in overcoming the many problems involved in its construction or in accomplishing the precision machine work required. Whatever the fascination, the undertaking is an interesting one.

Building a two-cylinder working miniature gas engine from the



ground up is a big undertaking. The wood patterns and complicated core boxes needed in having the castings made will be far more difficult to turn out than all the machine work on the little engine itself. The modelmaker who is not so well versed in pattern making can work from a set of readymade castings, as I did in building the engine shown in the photograph, Fig. 1.

The rough castings from which the engine was built are shown in Fig. 2. Wherever possible the castings were made of the light and hard aluminum alloy, Dural. This was done to keep the weight of the finished engine at a minimum. However, some of the smaller castings were made up in bronze where it was felt this

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The building yond the scop be accomplis maker, from this reason t built patterns give the begin work and skill set and help the skill and

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Fig. 5 show the various sr The main ce rotary valve, the upper rig needed for ca part. The ma the connectin

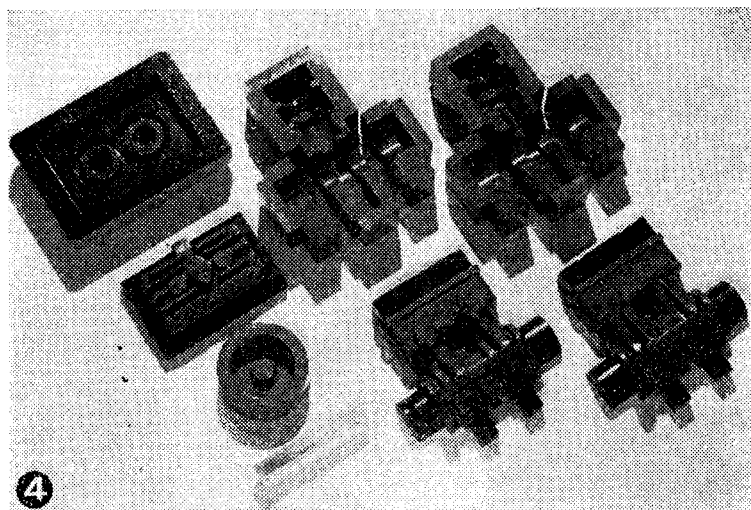
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metal would serve the purpose best. All these castings were made from the patterns and core boxes shown in the photos Figs. 3, 4 and 5.

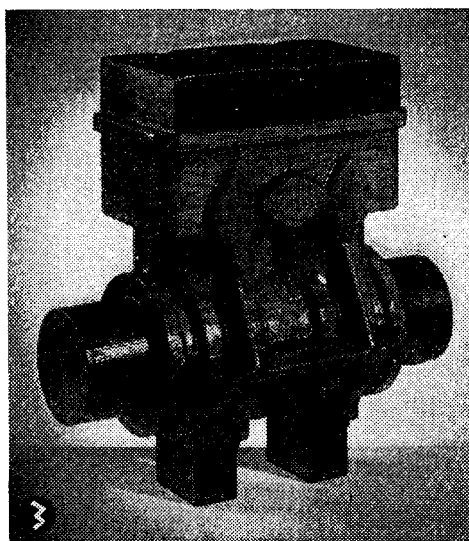
The building of patterns and core boxes is beyond the scope of this article, but the work can be accomplished, by the experienced model-maker, from the accompanying drawings. For this reason the complete set of professionally built patterns and core boxes is shown. It will give the beginner a good idea of the amount of work and skill required in constructing a similar set and help him decide whether or not he has the skill and experience to tackle the job.

The photograph, Fig. 3, shows the main cylin-



der block and crank-case pattern with its various core prints to allow it to be case hollow for the cylinder liners, crankshaft, water circulation space, transfer passages, etc. The photo, Fig. 4, shows this same main pattern with some of the necessary core boxes used in casting the various parts of the interior of the cylinder block and crank-case housing. It also shows the flywheel and cylinder head patterns and the core box for the cylinder top.

Fig. 5 shows the patterns and core boxes for the various small parts which are cast in bronze. The main center bearing, which also acts as a rotary valve, is shown by the two half-discs in the upper right corner along with the core box needed for casting the hollow intake ports in this part. The main end bearings, the rotary valve, the connecting rod and timer patterns can be

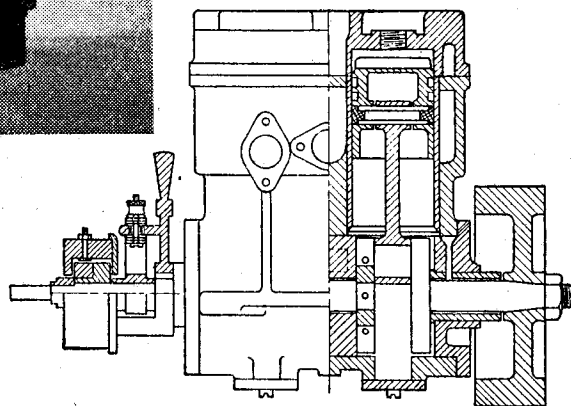


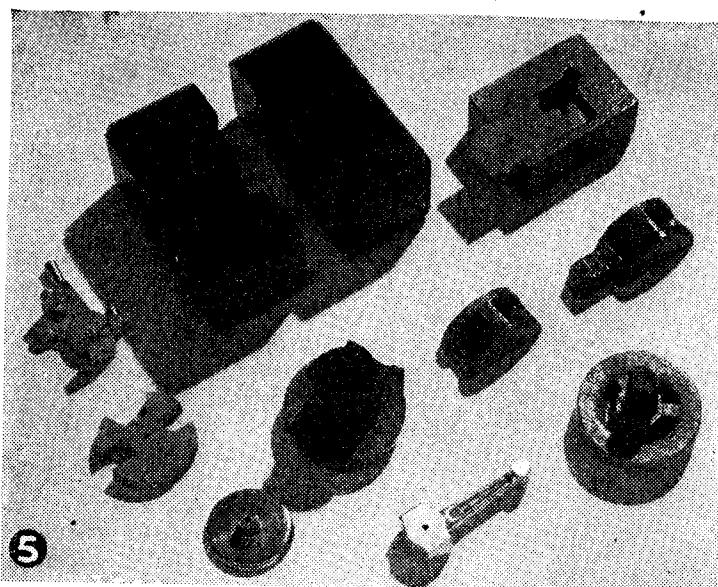
easily recognized, but the large black core box and the small circular part below it are not so easily made out. This is the pattern and core box for the pistons, and quite a fine job it is, for they must be made just so, with the proper wall thickness on the upper part to receive the rings while the lower skirt must be thinned down to reduce the weight of these reciprocating parts. The bosses for the wristpin must be cast on the inside and of course this must be allowed for in the core box. It can be readily seen from these photos that the patterns are complicated and their construction a little beyond the ability of the beginner who is not well experienced in the

art of pattern making. When I had a set of castings, I studied them well and compared them with the blueprints until the working of the little engine was thoroughly understood. Then, and only then, the machine work was started.

As so many of the engine's smaller parts are fitted to the main cylinder block, it seemed best to start the machine work on this main casting. It was first cleaned up slightly with a coarse file so it would sit level on the faceplate where it was firmly bolted, as in Fig. 6. Here the top of the casting was machined to proper height and faced smooth to form a compression-tight joint for the cylinder head. The position of the casting was shifted off-center on the faceplate, as in Fig. 7, where the holes for the cylinder liners were bored.

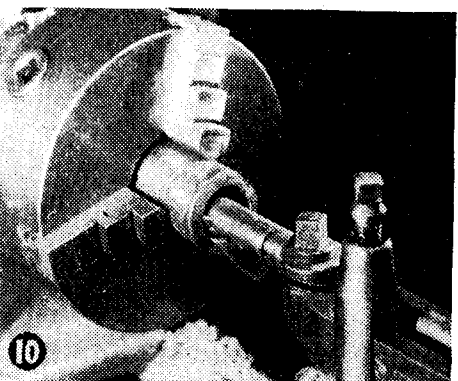
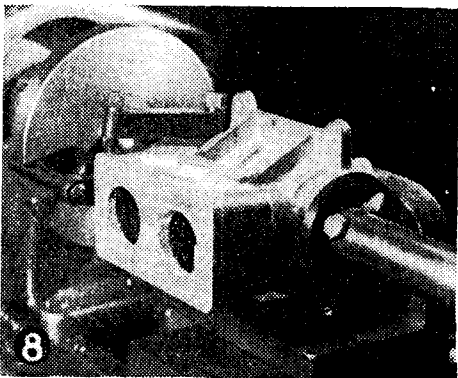
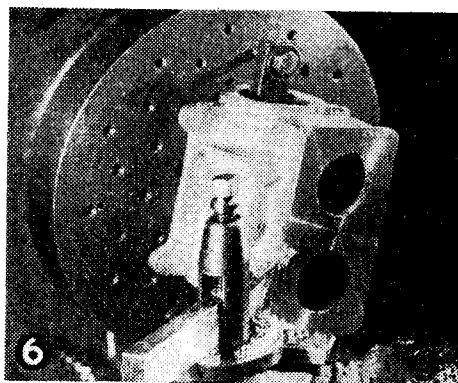
The photo shows a heavy steel disc mounted on the faceplate as a counterweight to balance the off-center work. This is good lathe practice as the boring can be accomplished at higher speeds and greater accuracy obtained. When one hole was bored accurately to size the casting was shifted, properly centering the other cylinder





hole, and this, too, was bored to match its mate exactly.

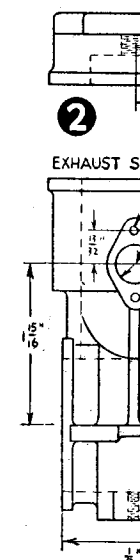
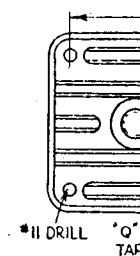
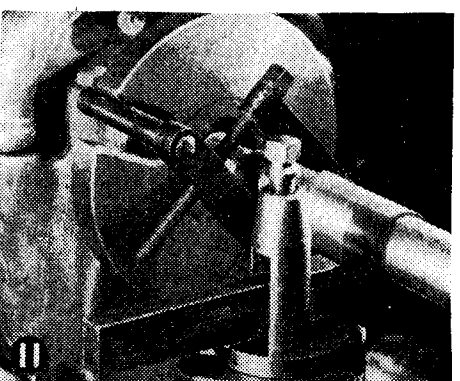
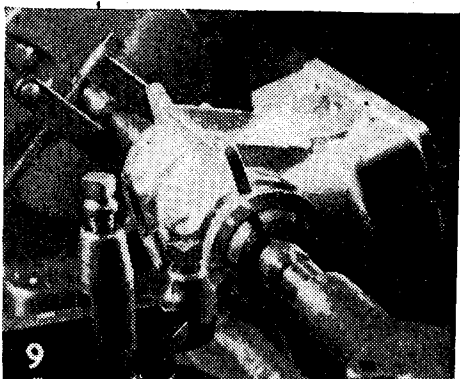
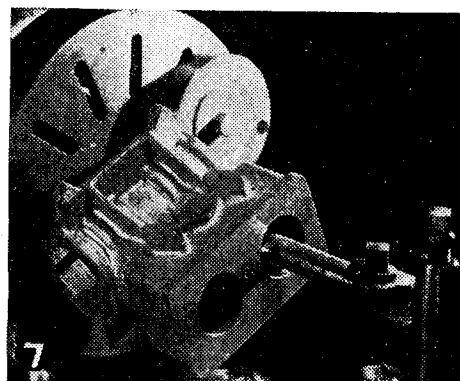
The casting was then mounted on an angle plate which was fastened to the cross slide of the lathe in place of the compound rest, as in Fig. 8, where the main bearing holes were accurately bored to receive the end bearing plates. This was accomplished by mounting a homemade boring bar between centers, driving it with a lathe dog and moving the work to the cutter by the carriage hand wheel. Light cuts were taken, the tool bit being adjusted several thousandths between cuts until the proper diameter was obtained. The work was then mounted on an expanding mandrel, as in Fig. 9, where the ends were faced



smooth to receive the end bearing plates.

The cylinder liners, made up from a cored stick of cast iron, were undertaken next. A solid bar can be used as well but it will require drilling before boring and will take slightly more work to complete than the cored piece. This was chucked in the three-jaw, as in Fig. 10, where the cylinder hole was bored smoothly and accurately to size. First a heavy roughing cut was taken to get under the oxide scale, and this was followed by several light cuts with very fine feed. The boring tool was freshly ground and keenly honed and a very fine power feed used for the final cut in the bore.

The work was then mounted on a mandrel held between centers, as in



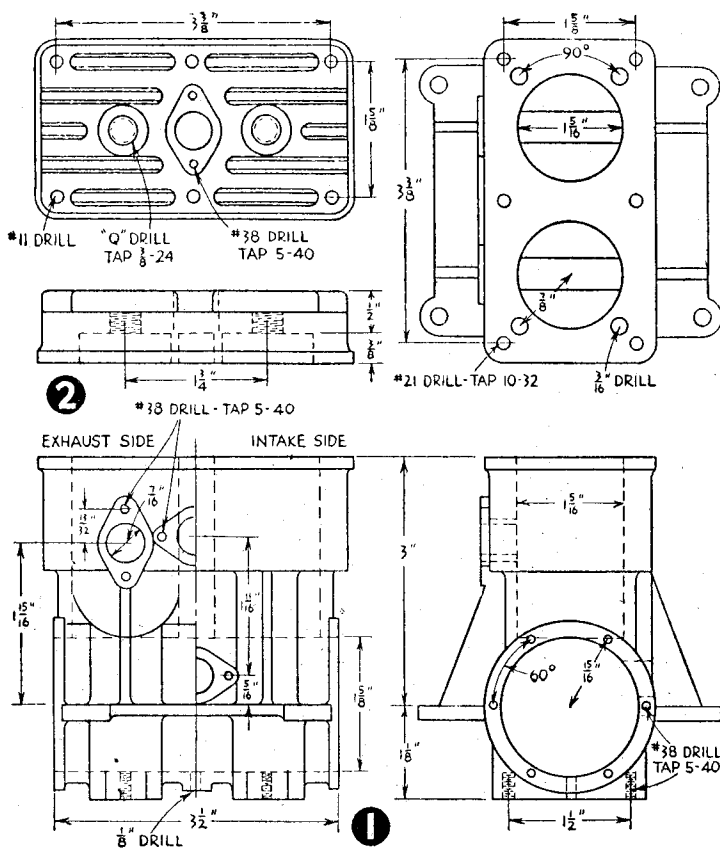
1. Main Bearing
2. Cylinder Liner
3. End Bearing
4. Piston (2)
5. Upper Connecting Rod
6. Lower Connecting Rod
7. Connecting Rod
8. Flywheel
9. End Bearing
10. Inspection
11. Cylinder Liner
12. Pipe Flange
13. Timer Lever
14. Timer Cam
15. Crankshaft
16. Valve-closers
17. Valve-operating
18. Wrist-pin
19. Wrist-pin
20. Cam
21. Timer Housing
22. Timer Ratchet
23. Timer Lever

Fig. 11, where the cylinder liner was turned to size. The cylinder liners were made up from a cored stick of cast iron. Several thousandths between cuts until the proper diameter was obtained. The work was then mounted on an expanding mandrel, as in Fig. 9, where the ends were faced

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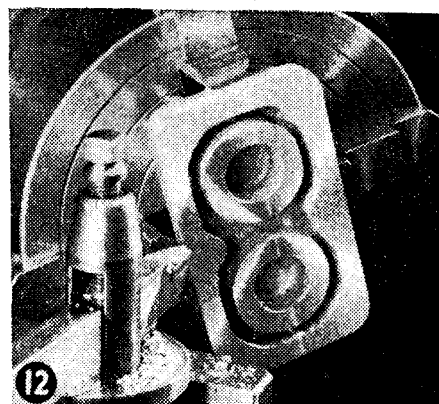
LIST OF MATERIALS

1. Main Body
2. Cylinder Head
3. End Bearing Plate (2)
4. Piston (2)
5. Upper Center Bearing
6. Lower Center Bearing
7. Connecting Rod (2)
8. Flywheel
9. End Bearing (2)
10. Inspection Plate (2)
11. Cylinder Liner (2)
12. Pipe Flange (4)
13. Timer Lever
14. Timer Cover
15. Crankshaft
16. Valve-closed Section (2)
17. Valve-open Section (2)
18. Wrist-pin (2)
19. Wrist-pin Plug (4)
20. Cam
21. Timer Housing
22. Timer Rotor Assembly
23. Timer Lock-nut

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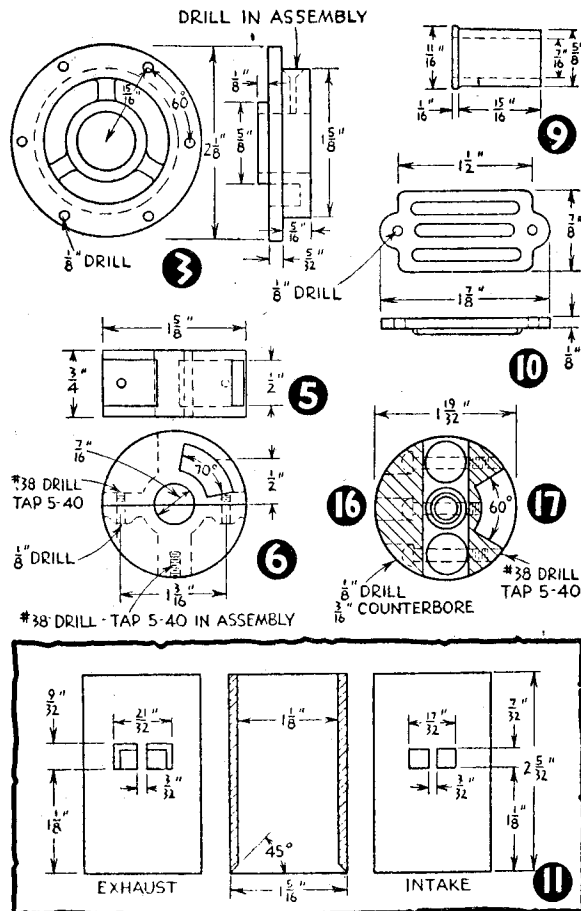
Fig. 11, where the outside of the sleeve was turned to exact diameter for a press fit in the cylinder block. Here again heavy roughing cuts were made to get the work down to within several thousandths of finished diameter. Then very light cuts were taken under a very fine power feed, carefully bringing the diameter to a good press fit in the cylinder bore.

If the liners are chilled, to shrink them, and the cylinder block heated in hot water, to expand it, the liners can be quickly pressed in



place between the jaws of a heavy vise. When the casting cools and shrinks around the liners they will be held permanently in place.

Machining the cylinder cover was a simple lathe job accomplished by chucking in the four-jaw, as in Fig. 12, where the lower surface was faced smooth and to proper thickness for mounting on the cylinder head. This is a typical shaper job, but where a lathe is the only machine tool in the shop it can be made to serve as well. In mounting the casting in the chuck the work was



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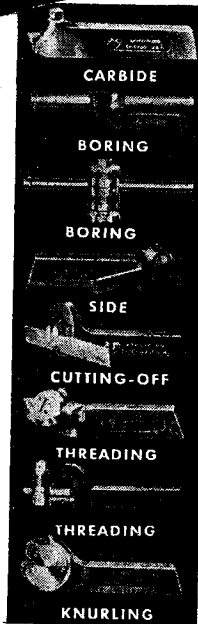
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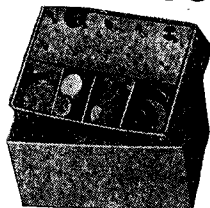
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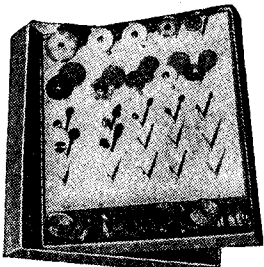
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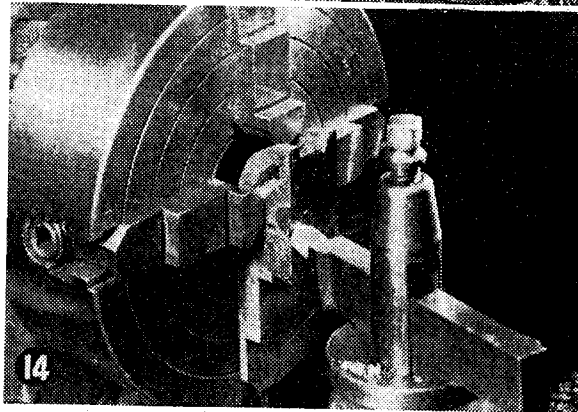
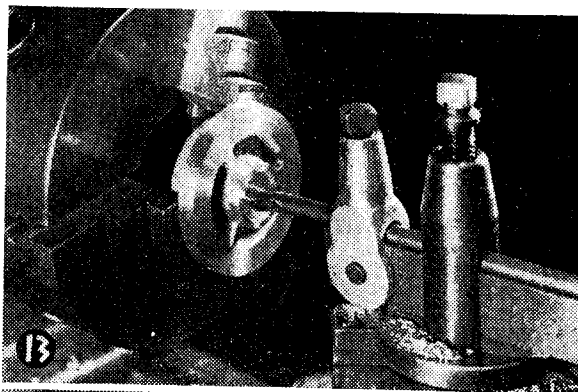


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held against the face of a drillpad, supported in the tailstock, and the jaws closed down on the work while its face was held accurately parallel with the chuck face.

Chucking flat work in this manner will help it to run dead true. The work should be carefully checked after the first roughing cut is made to see that the edges will be brought to an even thickness all around when the piece has been finally machined. The work was shifted off-center in the chuck for boring the gas chambers to fit exactly over the cylinder bores. The spark plug and screw holes were drilled in the drill press and when the spark plug holes were tapped the work on this piece was complete.

The end bearing plates were machined in the three-jaw chuck, as in Fig. 13, where the face and outer diameter were turned to size and the bearing hole accurately bored. The work was then slipped onto a mandrel held between cen-



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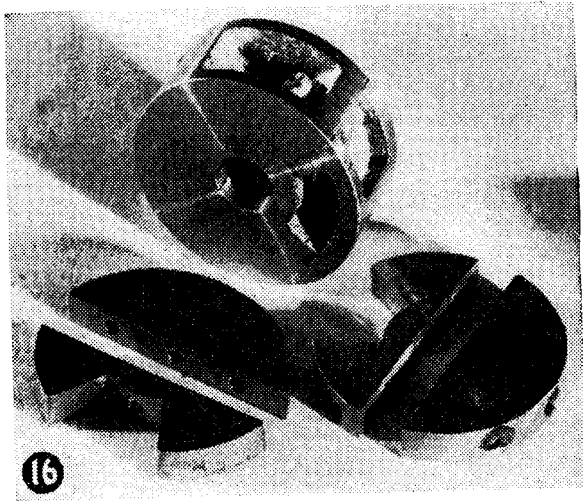
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The bronze bearings, which are pressed into the bored hole in the bearing plates, were machined in much the same manner, being first chucked in the three-jaw, drilled and reamed for the crankshaft and then mounted on a mandrel where the outside was brought to proper diameter for a good press fit in the bearing plates. With these made up and pressed in place, the oil holes, indicated in the drawings, were drilled in each bearing plate and through the bronze bearing bushing, as indicated in the sectional view of the assembly drawing.

The center bearing, which is part of the rotary valve, is made up in two parts from two separate castings. Each half was first chucked in the four-jaw, as in Fig. 14, where the joint between the two halves was machined smooth. The screw holes, indicated in the drawings, were drilled and tapped and the two parts fastened together on a mandrel, as in Fig. 15, where the side and outer diameter were turned accurately to the dimensions called for in the drawings. The completed part is shown in Fig. 16 along with the valves.

(This article will be concluded in the next issue of SCIENCE AND MECHANICS.)

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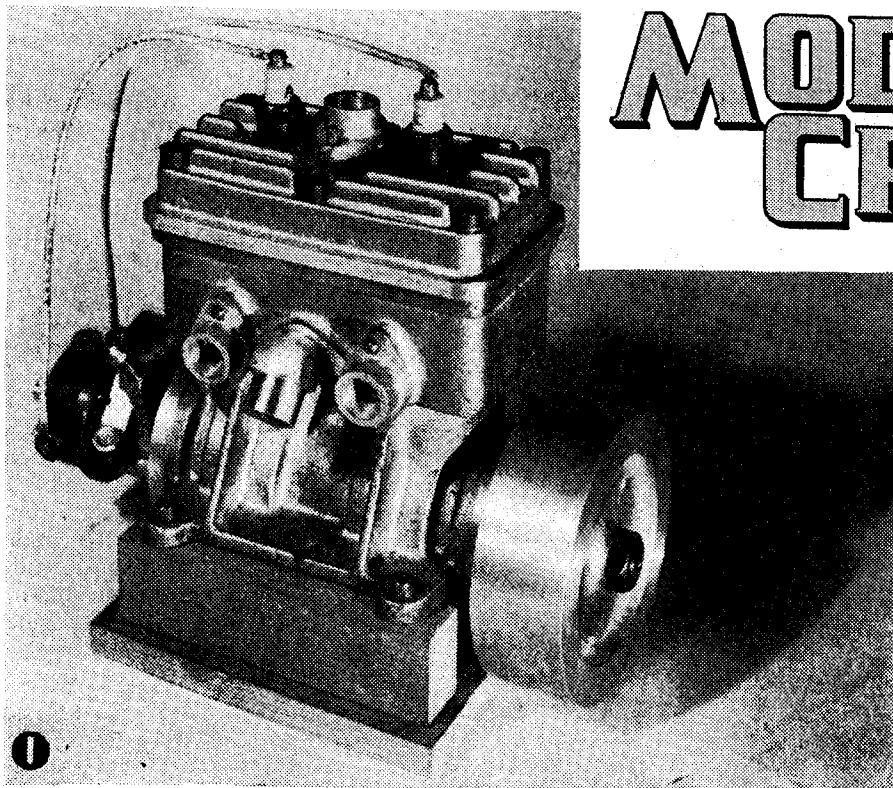
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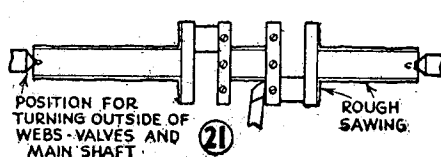
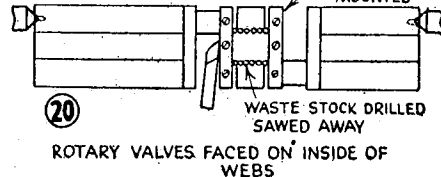
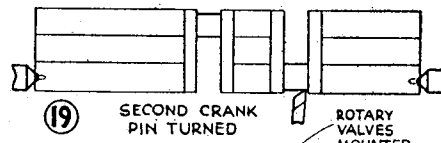
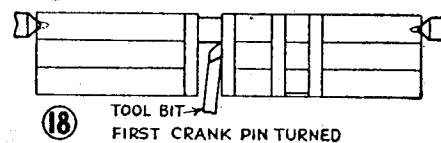
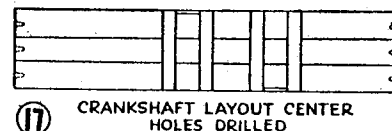
Building a Twin Cylinder RACING GAS ENGINE

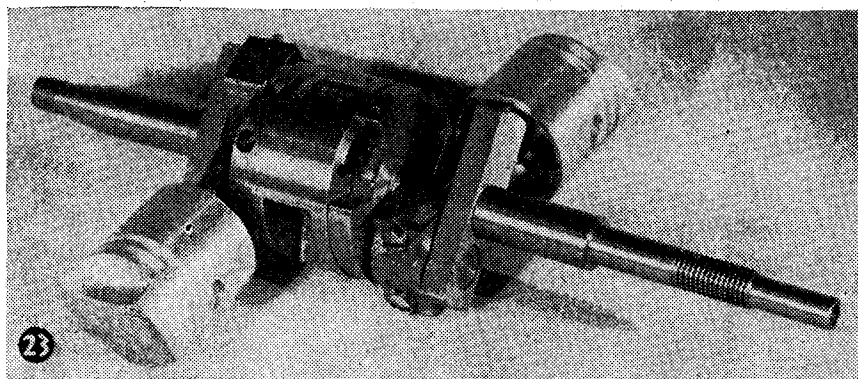
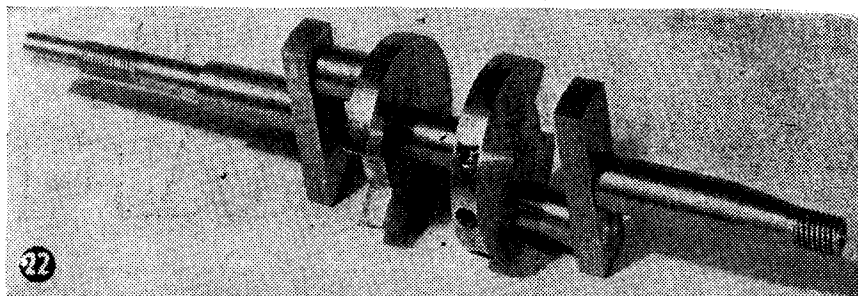
Part 2. Gary Moore completes the making of a beautiful model gasoline engine.

BY GARY MOORE
Craft Print Project No. 61

THE CRANKSHAFT of the little engine must be turned from solid steel bar stock to withstand the terrific pounding it will receive when running at high speeds. The built up type of crankshaft would soon break down under the hammering this little engine would give it. With the steel blank cut to proper length and the ends accurately squared and smoothly faced the dimensions in the drawings were carefully transferred to the work first laying out the important center lines, as indicated in fig. 17, and carrying them around on the ends of the stock to accurately locate the center holes for mounting the work between centers when turning the crankpins and the main part of the shaft itself. With the work completely laid out, and the lines deeply scored with a sharp scribe, the three center holes on each end were accurately drilled, care being taken to bring them all to the same depth. The steel blank was then mounted between centers in the lathe, as indicated in the drawing, fig. 18, where one of the crankpins was turned to exact diameter and the inside of the webs faced smooth to within

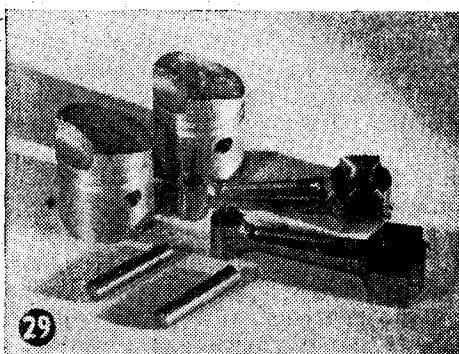
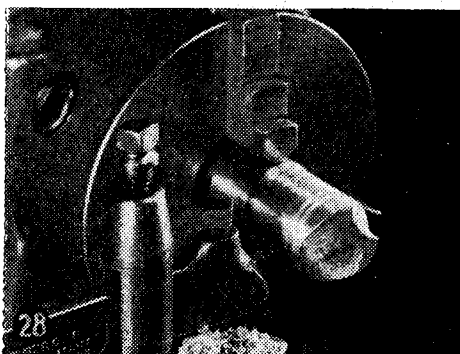
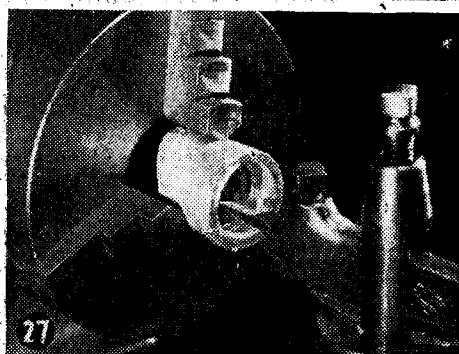
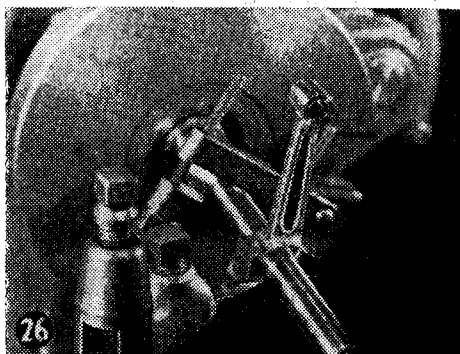
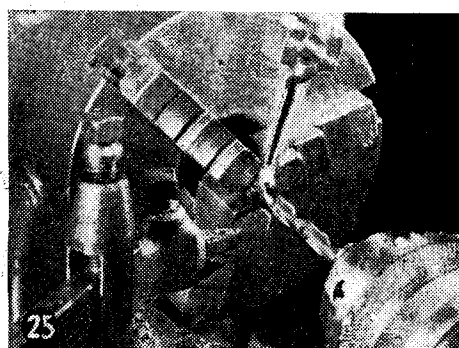
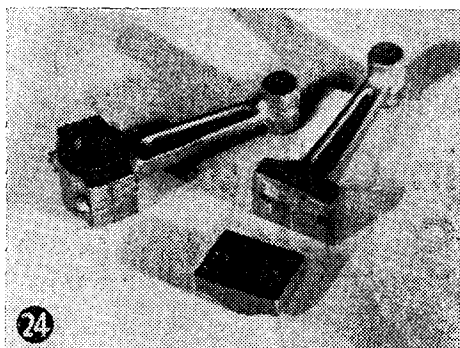
several thousandths of their final width to allow for facing after the rotary valves have been attached. The work was then shifted with the lathe centers in the opposite center holes, as indicated in fig. 19, where the second crankpin was machined in the same manner as the first. The waste stock between the two crankpins was cut away, as shown in the drawing, fig. 20, and the castings for the rotary valves were mounted in place. These castings were first sawed in two and the flat surfaces at the joint machined smooth and true for





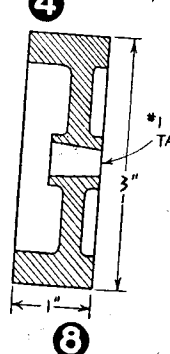
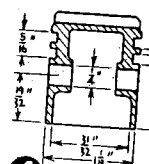
no longer needed. The work was again replaced in the lathe, fig. 21, where the main shaft was brought to the dimensions in the drawings and the opposite side of each rotary valve faced smooth along with the crank webs bringing both to their proper thickness. The outer edges of the valves were faced smooth and turned to exact diameter and at the same time the ends of the crank webs were nicely rounded and all brought to exactly the same length. The ends of main shaft reduced in diameter, as indicated in the drawings, and the threads cut with the

a perfect fit on the crank webs. Two of the valve parts were drilled and counter-bored and the other two drilled and tapped to receive the three screws which hold them in place on the crank webs. The size and location of these screw holes are clearly laid out in the drawings. With the rotary valves fastened in place the work was again mounted between centers where the inside surfaces of the valves were faced smooth and the webs brought to their final thickness. When the inner faces of both sets of crank webs were machined the work was removed from the lathe and the waste stock on either side of the main shaft was cut away including the crankpin center holes as they were



work was again replaced in the lathe, where the main shaft was brought to the dimensions in the drawings and the opposite side of each rotary valve faced smooth along with the crank webs bringing both to their proper thickness. The outer edges of the valves were faced smooth and turned to exact diameter and at the same time the ends of the crank webs were nicely rounded and all brought to exactly the same length. The ends of main shaft reduced in diameter, as indicated in the drawings, and the threads cut with the

In machine connecting the first of the screws was to drill the big end before turning the part after

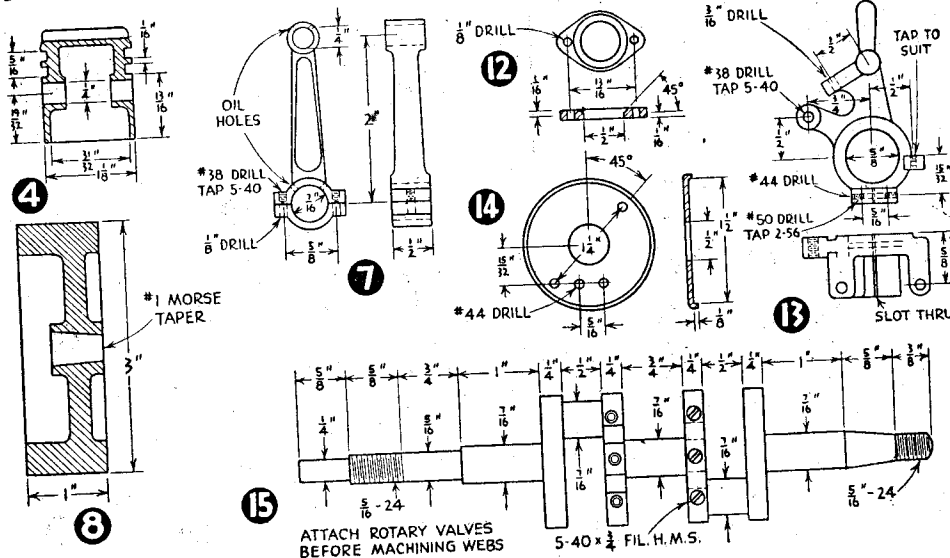
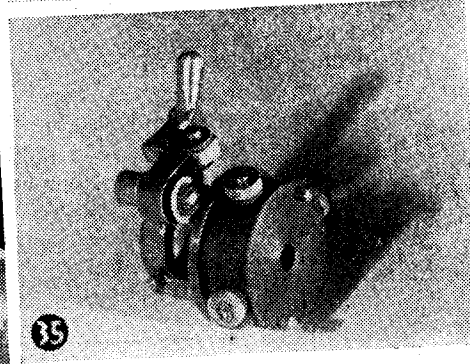
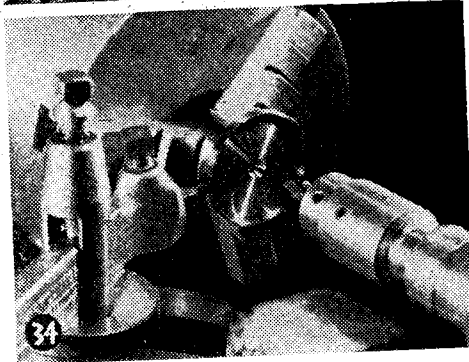
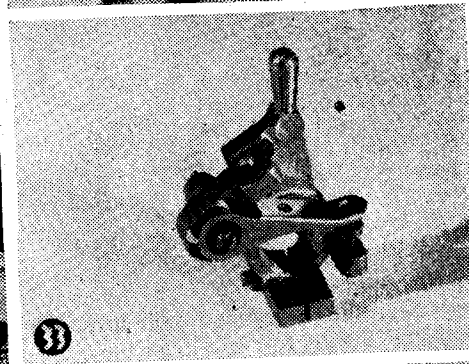
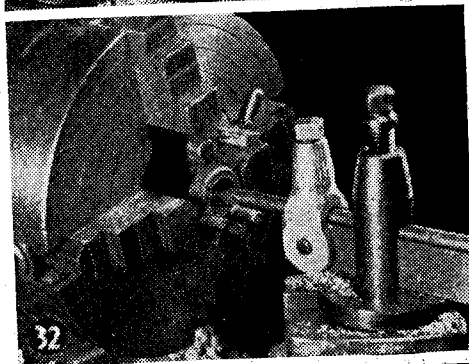
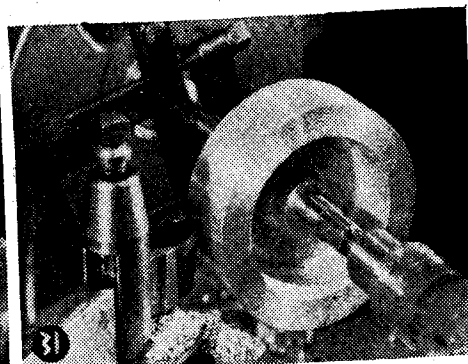
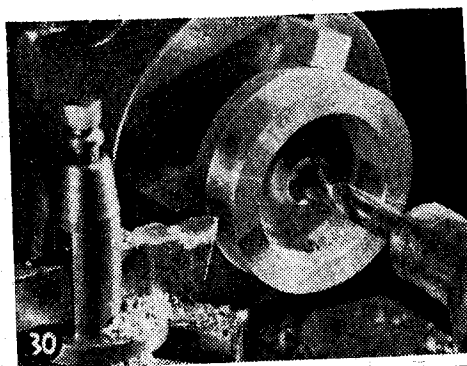


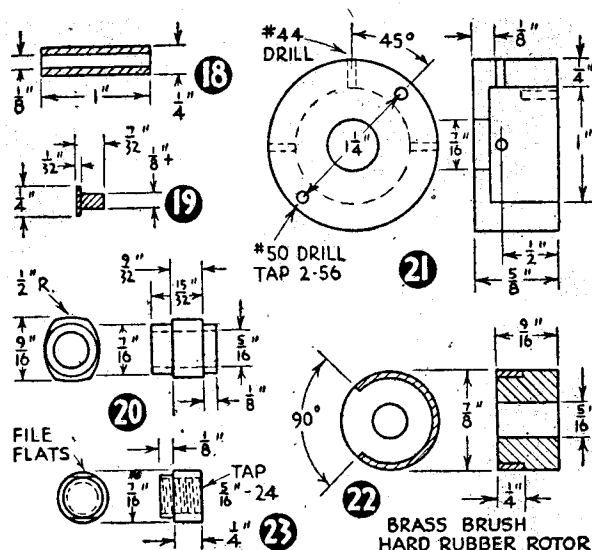
work still in the lathe. The fly-wheel end of the shaft was beveled to match the tapered hole in the flywheel and the tip of the shaft threaded for the retaining nut. As each of the crank-pins and the three sections of the main shaft were turned to final diameter they were brought to a smooth finish with a fine Swiss file and polished with fine well worn emery cloth. The completed crank-shaft, with rotary valves attached, is shown in the photo, fig. 22, and again in the photo, fig. 23, with the center bearing, the connecting rods, and their pistons mounted in place ready for final assembly.

In machining the connecting rods the first operation was to drill the two screw holes on the big end before cutting the bearing cap off. This makes the work easier and accurately aligns the holes in each part after the cap has been cut off and the flat

surfaces at the joint machined smooth. The screw holes in the big end of the rod were then tapped while those in the cap were opened out to clear the

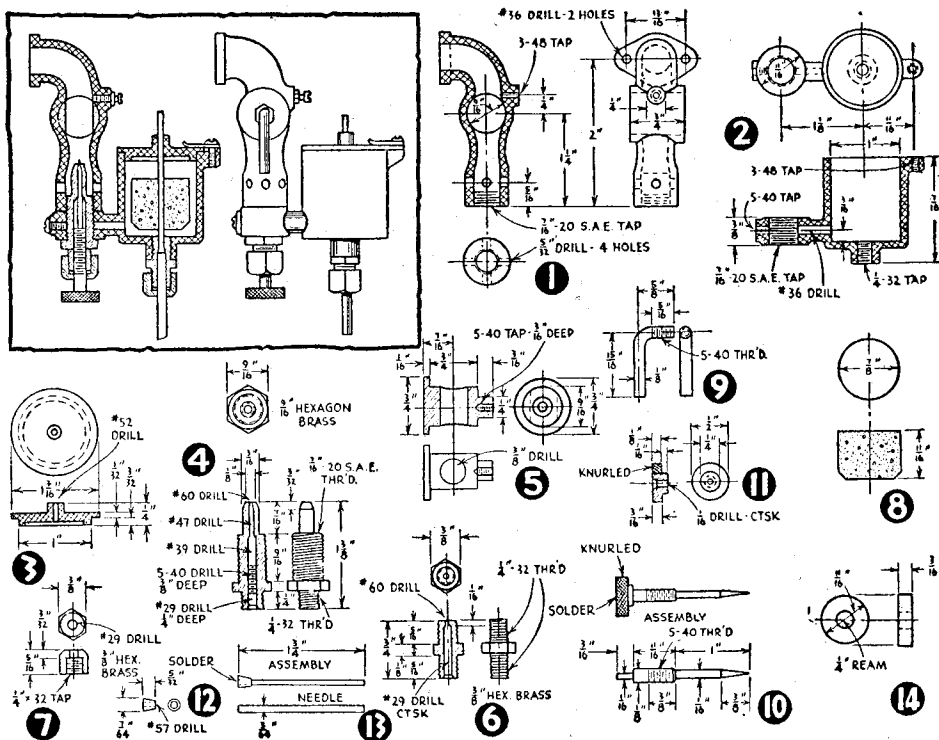
screws. The photo, fig. 24, shows one of the rods with the cap cut off and the holes drilled and threaded while the other rod has the cap screw fastened in place and the big end drilled for the crank pin. The work was next chucked in the three-jaw, as in fig. 25, where the wrist pin hole was drilled and reamed to final size. The connecting rod was then mounted on





a mandrel, as in fig. 26, where the sides were faced smooth and brought to the proper width to fit between the webs on the crankshaft. The rods were then cleaned up with a fine file and polished bright for appearance.

The pistons were machined by first chucking in the three-jaw, as in fig. 27, where the inside of the lower skirt was accurately bored to size and the lower edge faced smooth. The work was then mounted on a stub mandrel made up from a short steel bar while held in the chuck, as in fig. 28, where the outer diameter of the piston was turned to a nice sliding fit in the cylinder bore and the ring grooves cut in with a parting tool. The top of the piston was smoothly finished with a fine file and emery cloth and the wrist pin hole accurately located, center punched and drilled with the piston supported in the crotch center of the lathe. If a crotch center is not available and the drilling must be done in the drill press great care should be used in dividing the work and accurately locating the hole to be drilled in from each side. It is well to use a smaller drill first, drilling in from each side and running a larger drill and reamer through both holes at the same time.



The two wrist pins were made up from drillrod, drilled hollow and the two brass ends made up and inserted following the dimensions on the drawings closely. These are shown, along with the completed pistons and connecting rods, in the photo, fig. 29.

The flywheel was machined almost entirely in the three-jaw chuck while mounted as in fig. 30. Here the inside of the wheel was bored, the hub turned to diameter and faced smooth and to proper length and the crankshaft hole drilled. The edge and face of the rim were rough turned and the work reversed in the chuck where the turning operations were repeated. The flywheel was then mounted on a mandrel, as in fig. 31, where a light facing cut

LIST OF MATERIALS—CARBURETOR

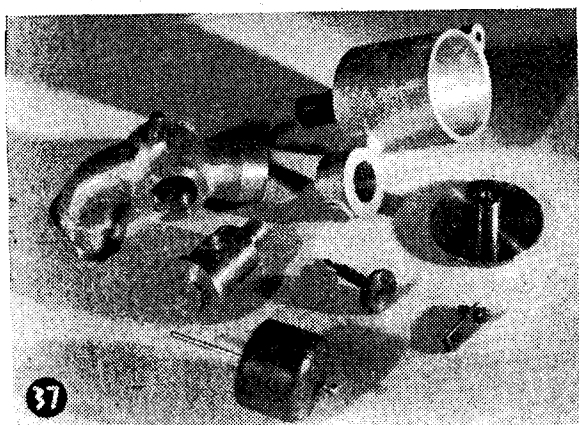
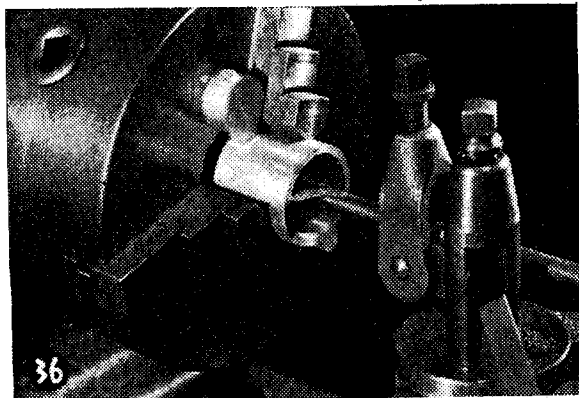
No.	Name of Part
1.	Carburetor Body
2.	Gasoline Chamber
3.	Gasoline Chamber Cover
4.	Carburetor Nozzle
5.	Throttle
6.	Float Valve Seat
7.	Union Nut
8.	Carburetor Float
9.	Throttle Lever
10.	Needle Valve
11.	Needle Valve Cap
12.	Float Needle Valve
13.	Float Needle Head
14.	Throttle Lever Spacer

MISCELLANEOUS MATERIALS

2	3-48x3/8" Filister Head Screws
1	3-48x1/4" Round Head Screw
1	5-40x1/4" Round Head Screw
1	5-40 Hexagonal Nut
1	3-40x5/8" Filister Head Screw & Hex. Nut
1	3/8 dia. x 1/8" Hole Washer

was taken on the sides and face of the rim to insure its being concentric with the crankshaft hole and running dead true. The wheel was then remounted in the three-jaw chuck and with a reamer held in the tailstock the shaft hole was taper reamed, as called for in the drawings, to match the taper turned on the end of the crankshaft. This operation was accomplished with care in mounting the wheel squarely in the chuck and in using the reamer and when the flywheel was finally mounted on the crankshaft it ran dead true.

The timer lever casting was mounted in the four-jaw chuck, as in fig. 32, where the large hole was bored for mounting it on the rear bearing of the engine. The balance of the work

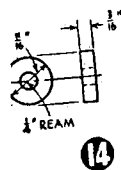
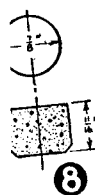
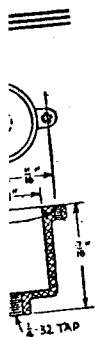


was accomplished in the drill press where the various holes were drilled and tapped for the screws which hold the breaker arm and contact points in place. An ordinary automobile breaker arm and contact points are used and these are shown mounted in place in the photo, fig. 33. The timer housing was made up from a small piece of hard rubber turned and bored to the dimensions in the drawings and drilled for the screws which hold it in place and the necessary binding posts. The rotor was also made up from hard rubber, turned to diameter and shouldered down part way to receive the brass brush as described and illustrated in the drawings. The timer cover was machined from a casting while held in the chuck, as in fig. 34, where it

was bored for a snap fit on the timer housing and the center hole drilled. The balance of the holes for fastening it in place, were drilled in the drill press the size and location of these being accurately laid out in the drawings. The completed fully assembled timer is shown in fig. 35.

The carburetor is built up from several castings with the balance of the parts made up from brass rod and other material found around the shop. Work was started on the gas chamber by chucking it, as shown in fig. 36, where it was bored to proper depth and diameter and the gas connection hole in the bottom drilled and tapped at this same chucking. The balance of the holes were drilled in the drill press following the dimensions in the drawings. The carburetor body casting was a little more difficult to machine. This required the use of an angle plate for facing the mounting flange with the work strapped to the angle plate and that in turn mounted on the faceplate of the lathe. In cross-drilling the large hole for the throttle the work was held in the four-jaw chuck where the hole was drilled and reamed to proper size and the boss faced smooth for a tight fit against the throttle flange and lever. The throttle was made up from bar stock, turned to the dimensions in the drawings and the intake hole cross-drilled. The gas chamber cover was machined from the casting furnished for this part, chucking by the lug cast on for this purpose, and turning to a good snap fit on the gas chamber. Reversed in the chuck the top was faced smooth and the lug cut partly away and the fine needle valve hole drilled. The main jet needle valve was made up from brass rod, turned to size and knurled and threaded and the hole drilled in its end for the nickel silver needle which was soldered in place. It was then filed to a fine point while the work was held in the chuck with the lathe running at high speed. The cork float was made up from an ordinary bottle cork chucked in the lathe and turned to shape with an ordinary sandpaper tool made by gluing a strip of sandpaper to a thin piece of wood. The hole for the needle valve was drilled and the cork given a thin coat of shellac. The needle valve was made up as described in the drawings and inserted in the cork float. The various other parts were made up from brass rod and other material found around the shop. The completed parts of the carburetor are shown in the photo, fig. 37, ready for assembly.

With the various parts of the little motor completed the final assembly began. Much hand fitting was required and great care was taken to see that each moving part worked properly without binding anywhere. The crankshaft with its rotary valve assembly was inserted in the crankcase and the rods with their pistons were fastened in place. The end bearing plates were slipped on the shaft and screw fastened to the crankcase, the carburetor was mounted to the intake flange of the cylinder block and the



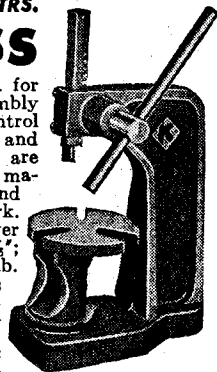
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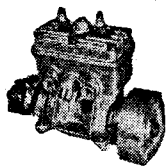
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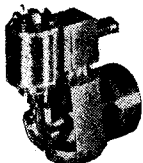
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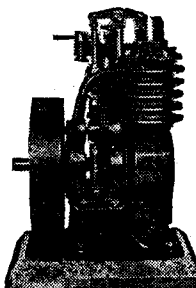
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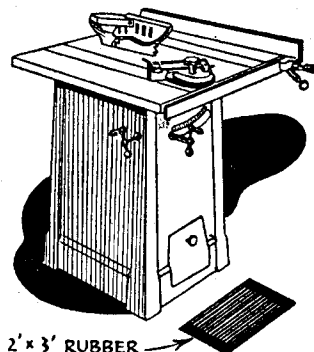
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cylinder head bolted on. The flywheel was mounted and the timer clamped in place. The sparkplugs were inserted and the electrical system hooked up according to the diagram in the drawings. The gas line was connected to the carburetor and gas tank and the job was complete. In giving the engine its initial tryout it was mounted on the edge of the work bench with the flywheel projecting over the edge far enough to allow a starting strap to be placed over the wheel and clear the bench. With the batteries hooked up and the switch closed, the carburetor needle valve opened several turns, and of course plenty of oil on the working parts, the engine was all set to go. The starting strap was placed over the flywheel, with one end held in each hand, and the engine backed up against compression. With a quick downward pull of the strap, spinning the engine forward, it finally took off under its own power and was kept running until properly adjusted and well broken in.

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